Application of e- beam lithography to FinFET based SRAMs

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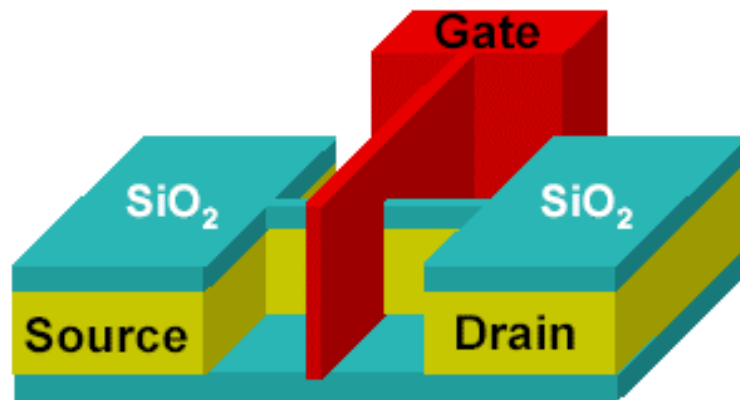### UC Berkeley
EE 290b Project
5/13/2003

Presentation outline

- Introduction to FinFETs

- SRAM Layout / design rules

- Lithography Process details

- Results

- Discussion – Intermediate range scattering effect in dense layouts

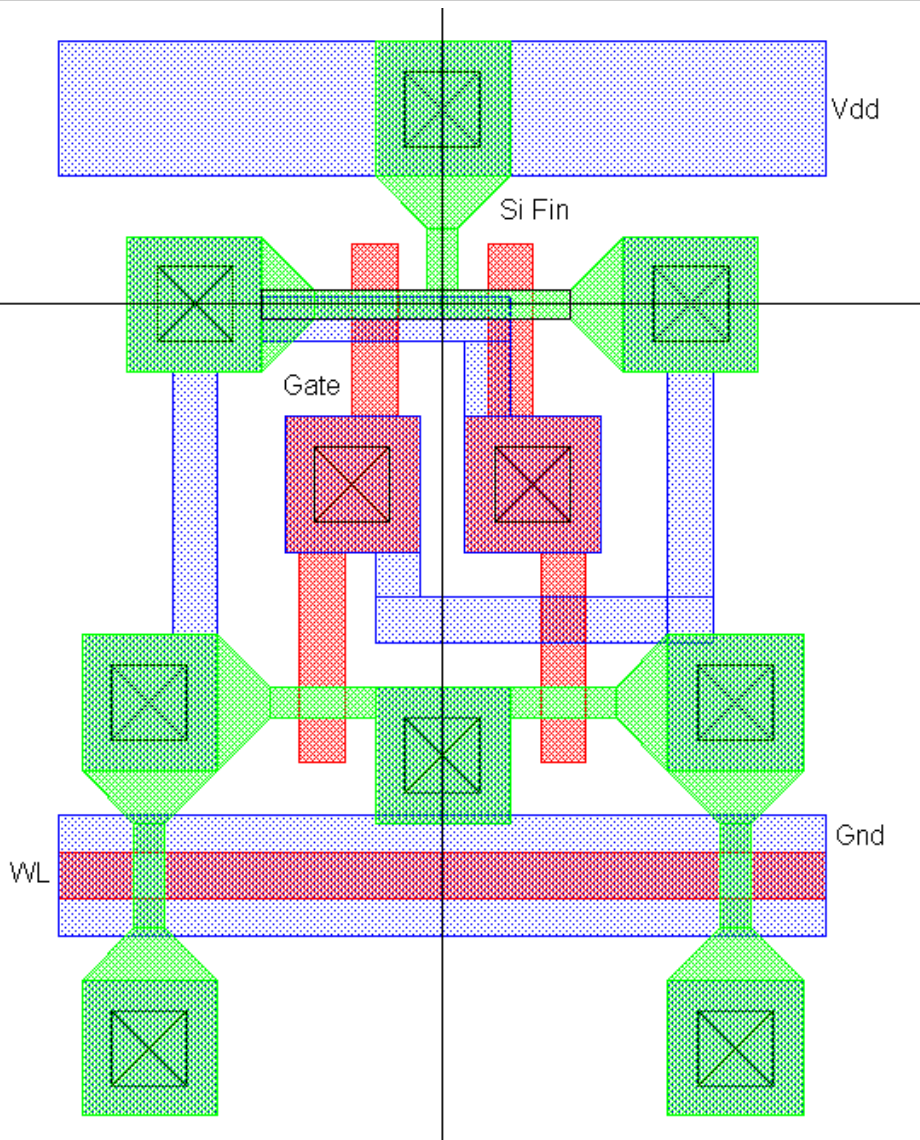- Conclusions

FinFETs based SRAMs

Advantages of FinFETs

- Continue MOSFET scaling: Can scale down to 10 nm

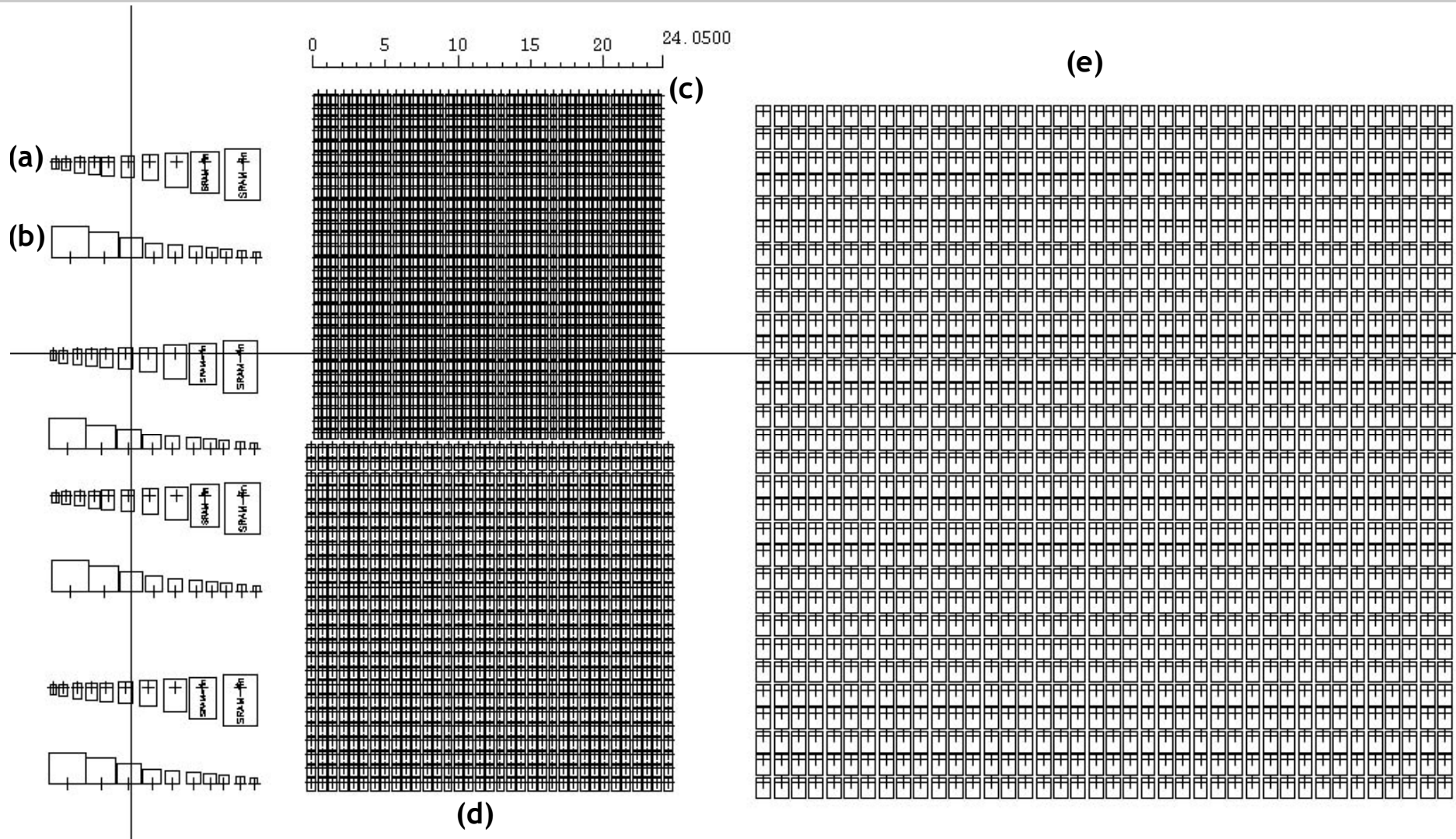- Good control of short- channel effects

For SRAMs

- Potentially higher density

- Low leakage + high performance

SRAM Cell

Layout Parameters	Minimum size
Si fin line width	20 nm
M1 line width	30 nm
M1 spacing	30 nm
misalignment tolerance between (fin / gate layer)	20 nm
M1 contact size	50 nm
M1-M2 via	90 nm

SRAM Test Layout

Lithography Process

| Process	Parameters	Comments
Spin AZPN114	(15%) at 2000 rpm,	thickness – 2000 Å
Crosslink bake	250 °C for 5 min	
Spin 1.8% HSQ	2000 rpm	HSQ thickness - 30 nm
Oven bake	170 °C for 5 min.	
Expose wafers in the nanowriter	Dose varying from 900 $\mu C/cm^2$ to 1800 $\mu C/cm^2$	(5 x 5 matrix) in geometric progression
Develop	60 secs in LDD26W, DI rinse	
O_2 ICP directional etch	-100 °C for 60 secs	transfer HSQ pattern to the AZPN layer. SEM to measure linewidths
HSQ removal	5:1 buffered HF for 3 secs	Measure linewidths with SEM
AZPN Resist Ashing – isotropic etching	in O2 plasma (ashing) for 1min	Measure linewidths with SEM. initial line widths reduced by about 3 nm
Si fin RIE etching	Cl_2/HBr recipe	etched 2000 A –SEM to measure line widths

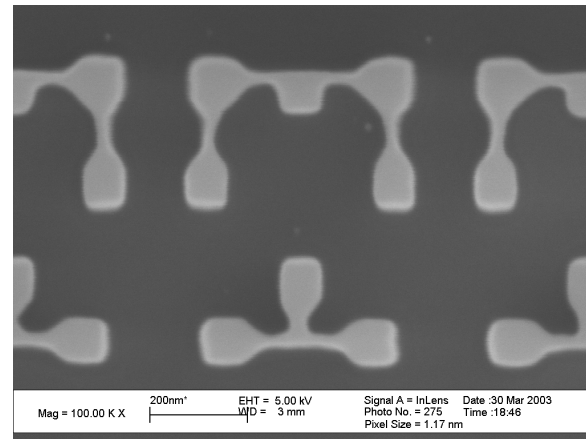# Isolated devices vs. dense arrays
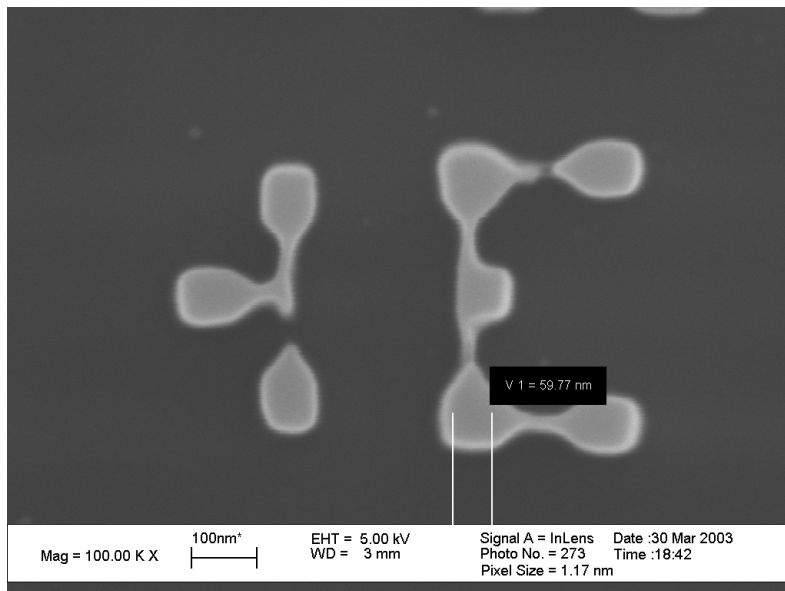
856 μc/cm^2

915 μc/cm^2
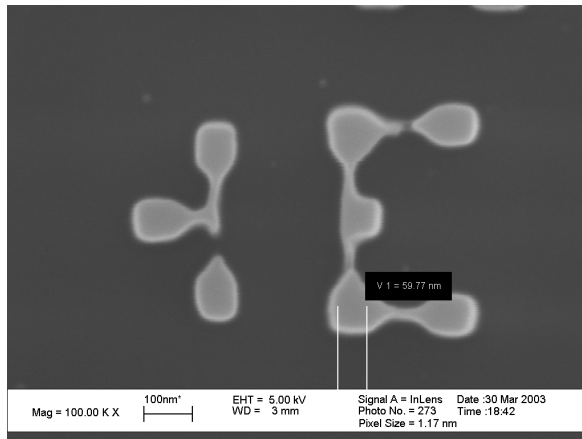
broken
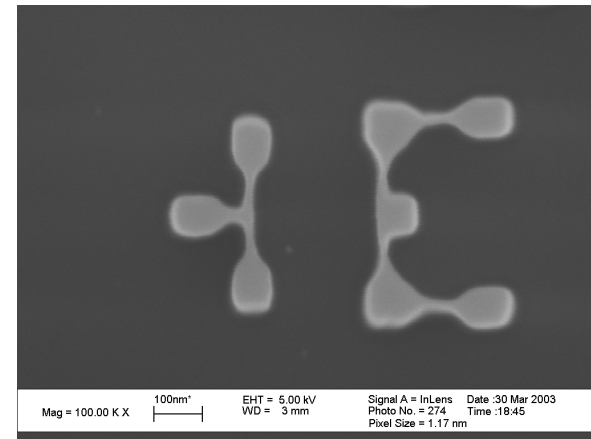
18 nm
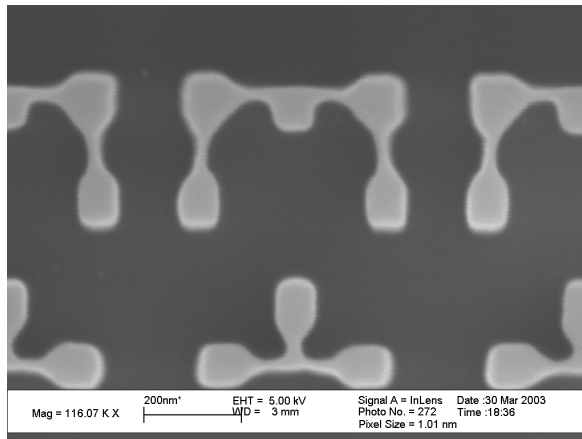
21 nm

23 nm

Pattern dependence

Fin vs. Gate isolated patterns

underexposed

Dose – 855 μC/cm^2
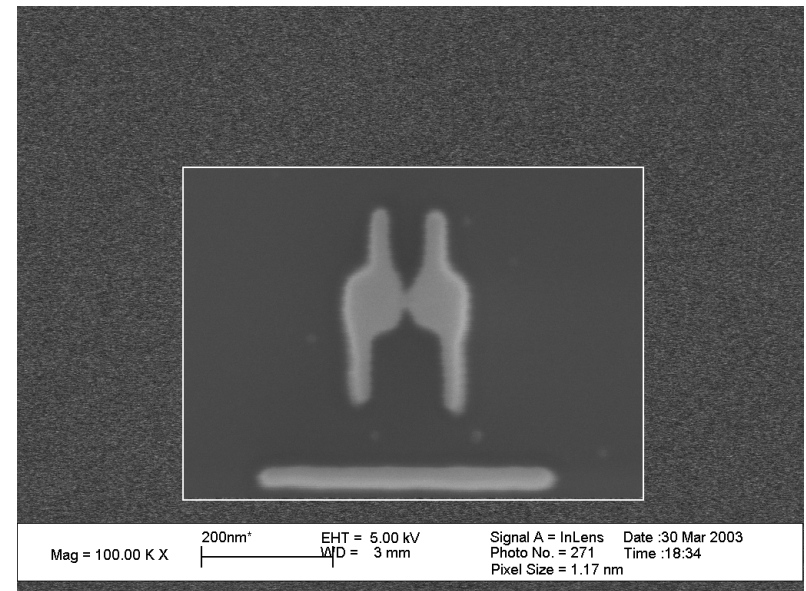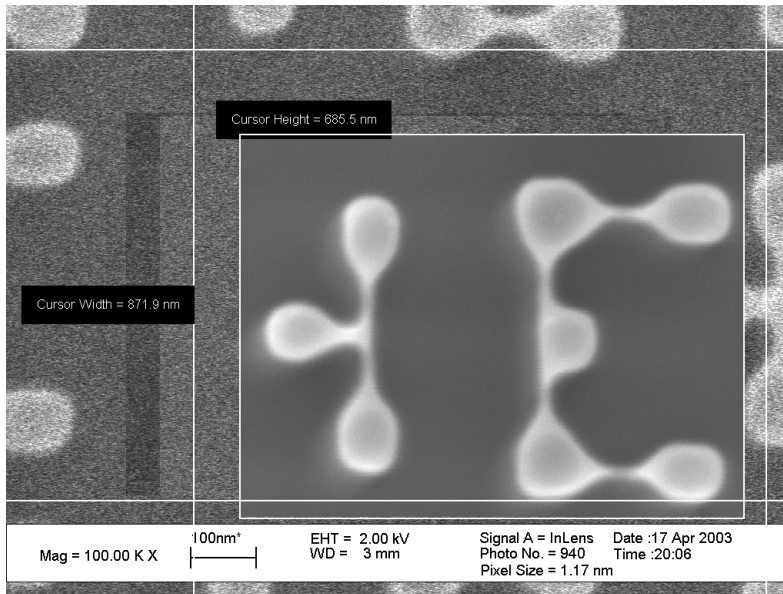

overexposed

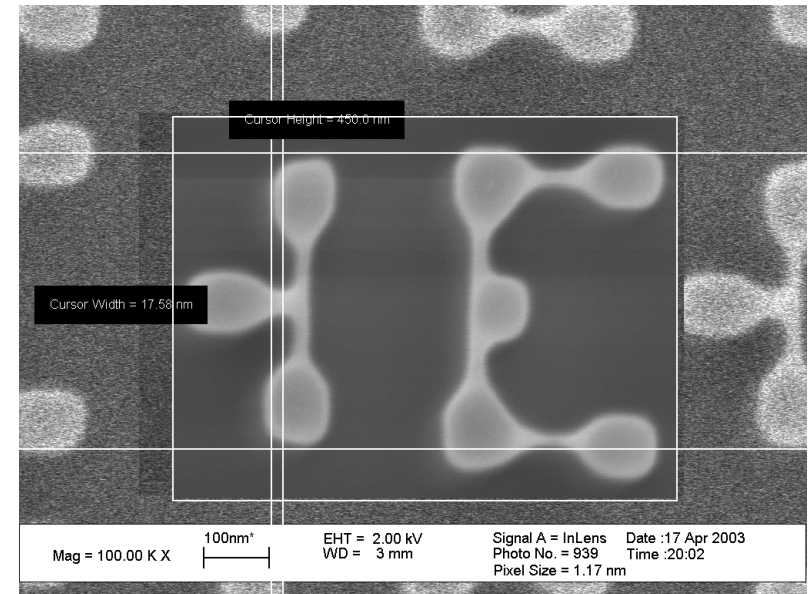Dose – 827 μC/cm^2

Pattern dependence (contd.)
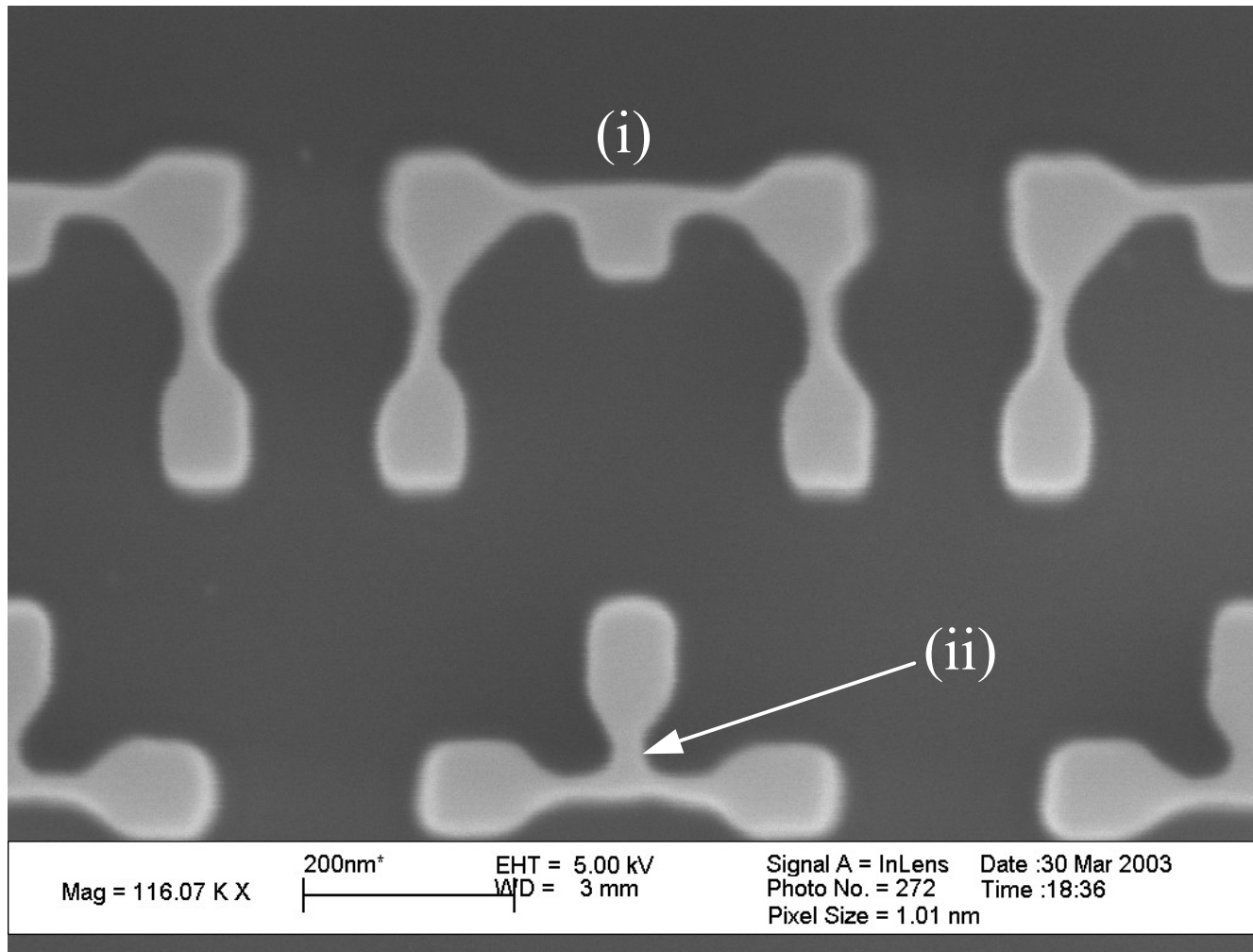
Regions
(i) and (ii)
⇓
higher dose

Position dependence

**Array Corner
– thinner lines**

**Array Center
- thicker lines**

**Array Center has received a higher dose than the corners
(SEM pictures taking after Si etch)**

Lines after etching are thicker – resist feature was tapered

Discussion

- Backscattering is already corrected for in the layout.

- Proximity effects - Dose is higher due to intermediate range scattering due to energetic secondary electrons.

    - Occurs in the range of 10x - 100x nm.

    Dose variation

    center of dense array > corner of dense array > isolated devices

- Pattern dependence – neighboring features get a higher dose if there is a large area exposed (like contact pads) nearby.

- Pattern dependent exposure of HSQ

Conclusions

- **e- beam lithography is a powerful tool to fabricate nanoscale FinFET based SRAMs**

- **Patterning dense layouts with uniform feature sizes is non-trivial**

- **Intermediate range scattering effects become important**
    - **proximity correction may be necessary**